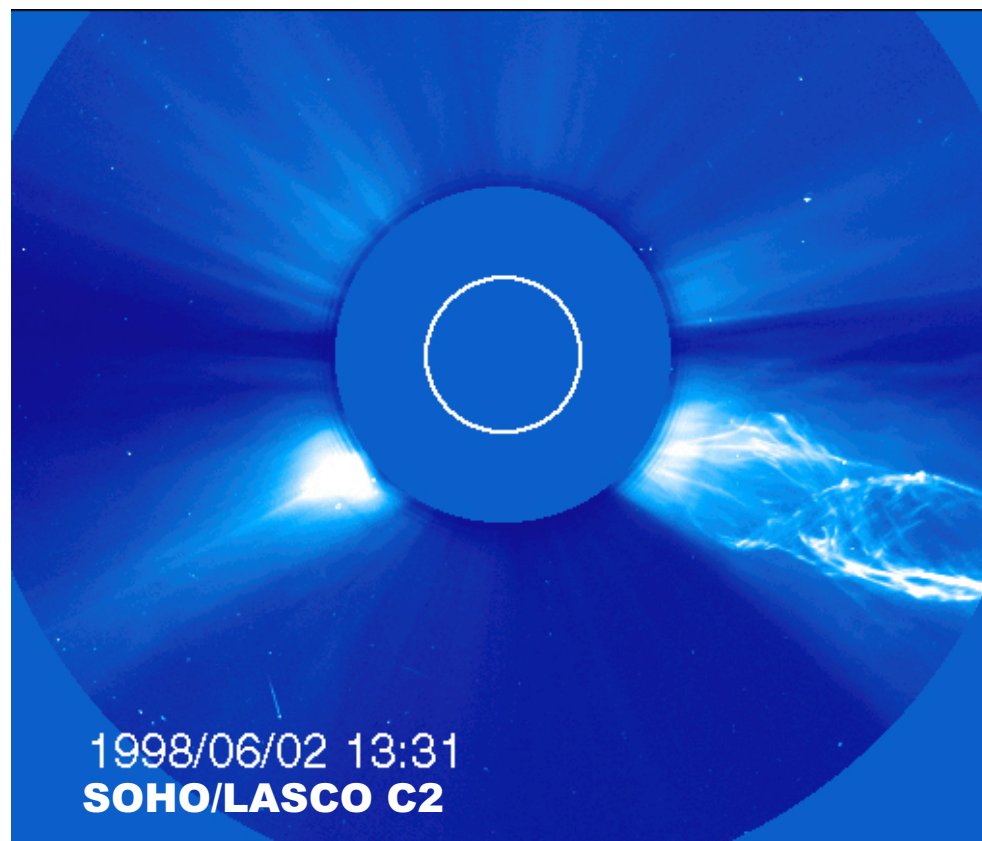
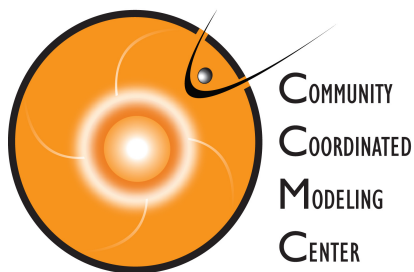


# CME Analysis with SWPC\_CAT for Space Weather

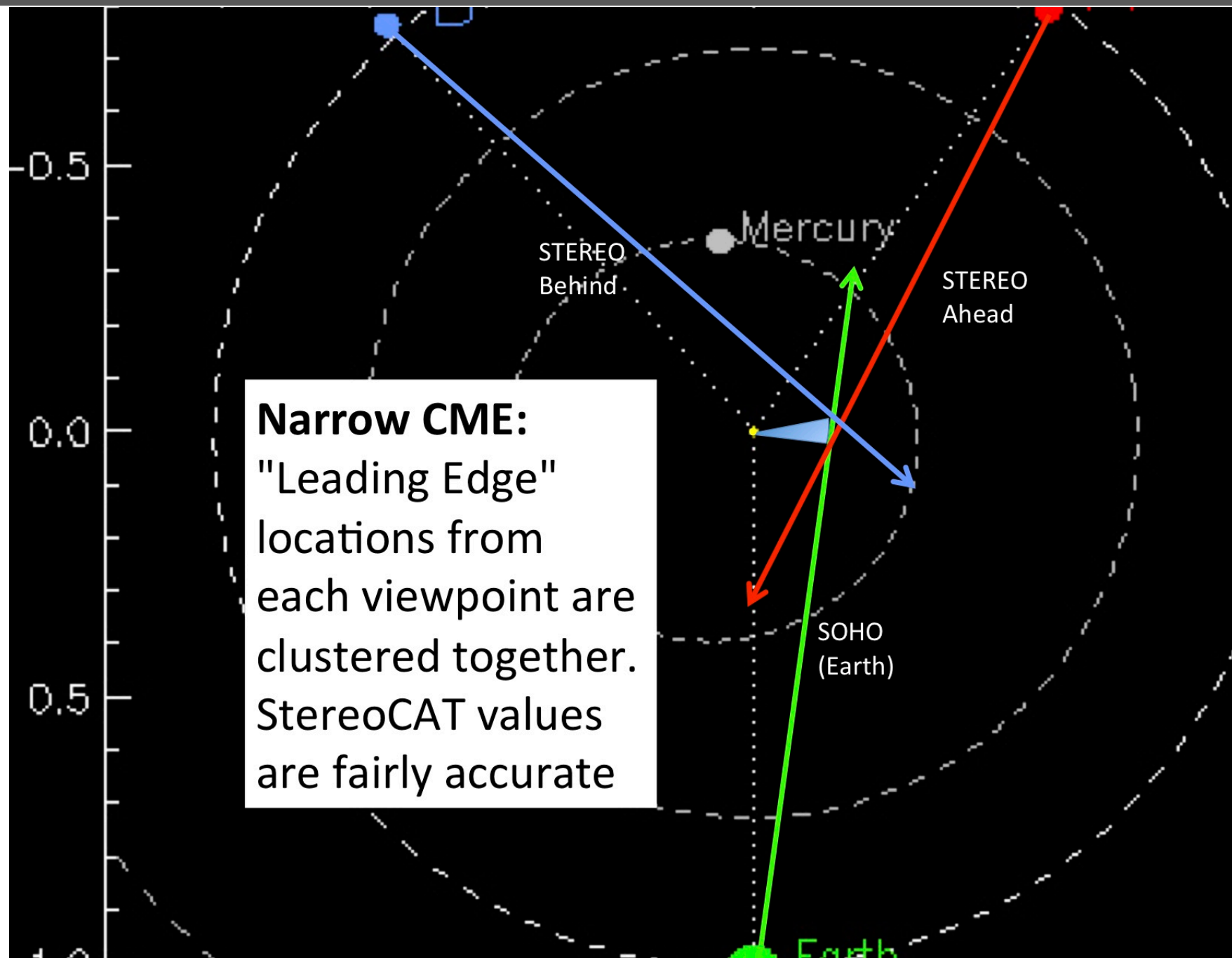


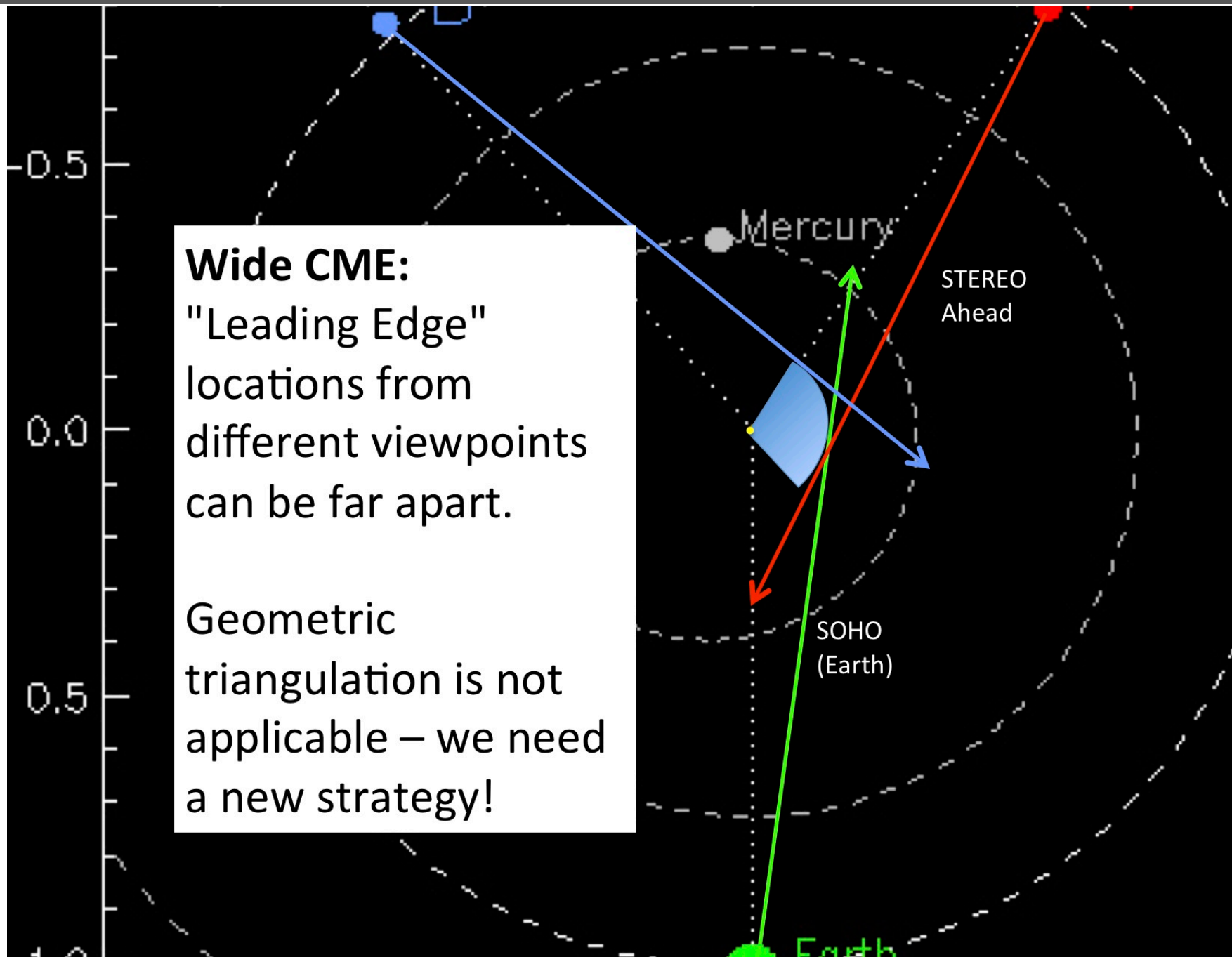
*Barbara Thompson, M. Leila Mays*

# Geometric Triangulation

Stereo CAT assumes you are measuring the same feature in two coronagraphs. It uses simple geometric relations to derive CME position and speed.

Unfortunately, the wider a CME is, the less likely it is that you're measuring the same feature. The leading edge from one viewpoint can be far away from the leading edge as seen from another viewpoint.





## Wide CME:

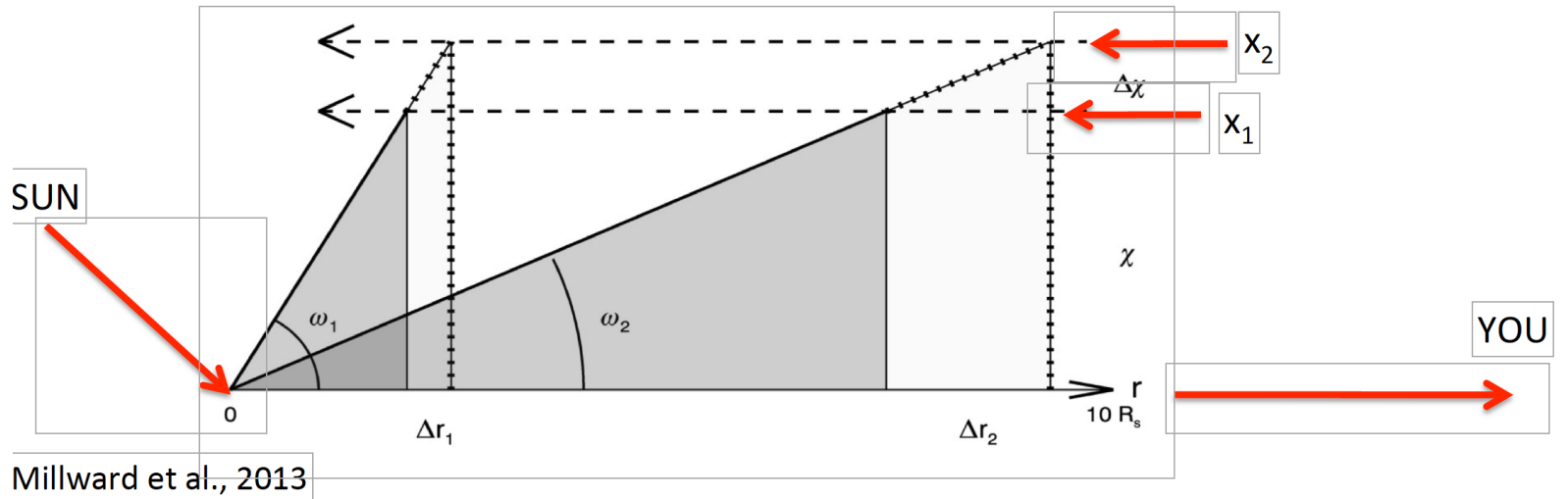
"Leading Edge"  
locations from  
different viewpoints  
can be far apart.

Geometric  
triangulation is not  
applicable – we need  
a new strategy!

# Geometric Triangulation

- So, for *wider CMEs* your Stereo CAT measurement is unreliable.
- But *faster* CMEs also tend to be *wider*, so Stereo CAT becomes less applicable for *fast CMEs* as well.
- And there are issues with *Halo CMEs*. *Let's look at one issue, the 'Half-angle – radial distance' conundrum.*

# Geometric Triangulation

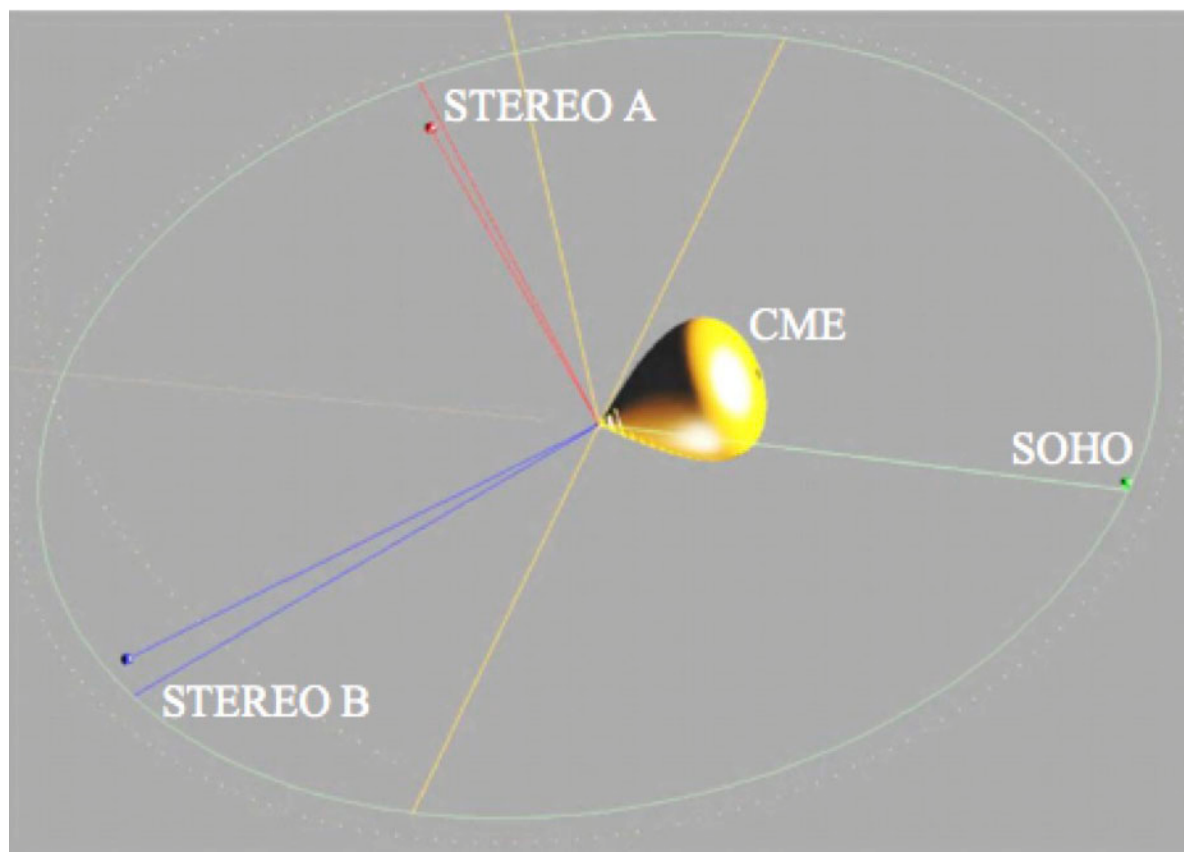


When you see a Halo CME you see the sides, not the leading edge.

The CME on the left is faster and wider, the one on the right is slower and narrower. However, the observer (You) will measure the same change in distance  $|x_2 - x_1|$  and derive the same plane of sky speed. To determine the 3D speed you need to know the CME width (which you might not know).

# How do we fix this?

We can use a model of a 3D CME shape and project that model from the different viewing angles. The easiest version of this is SWPC\_CAT.



# The best of both worlds: SWPC\_CAT

SWPC\_CAT performs the triangulation measurements like StereoCAT does, but it uses **3D projection geometry**, similar to the cone projection model.

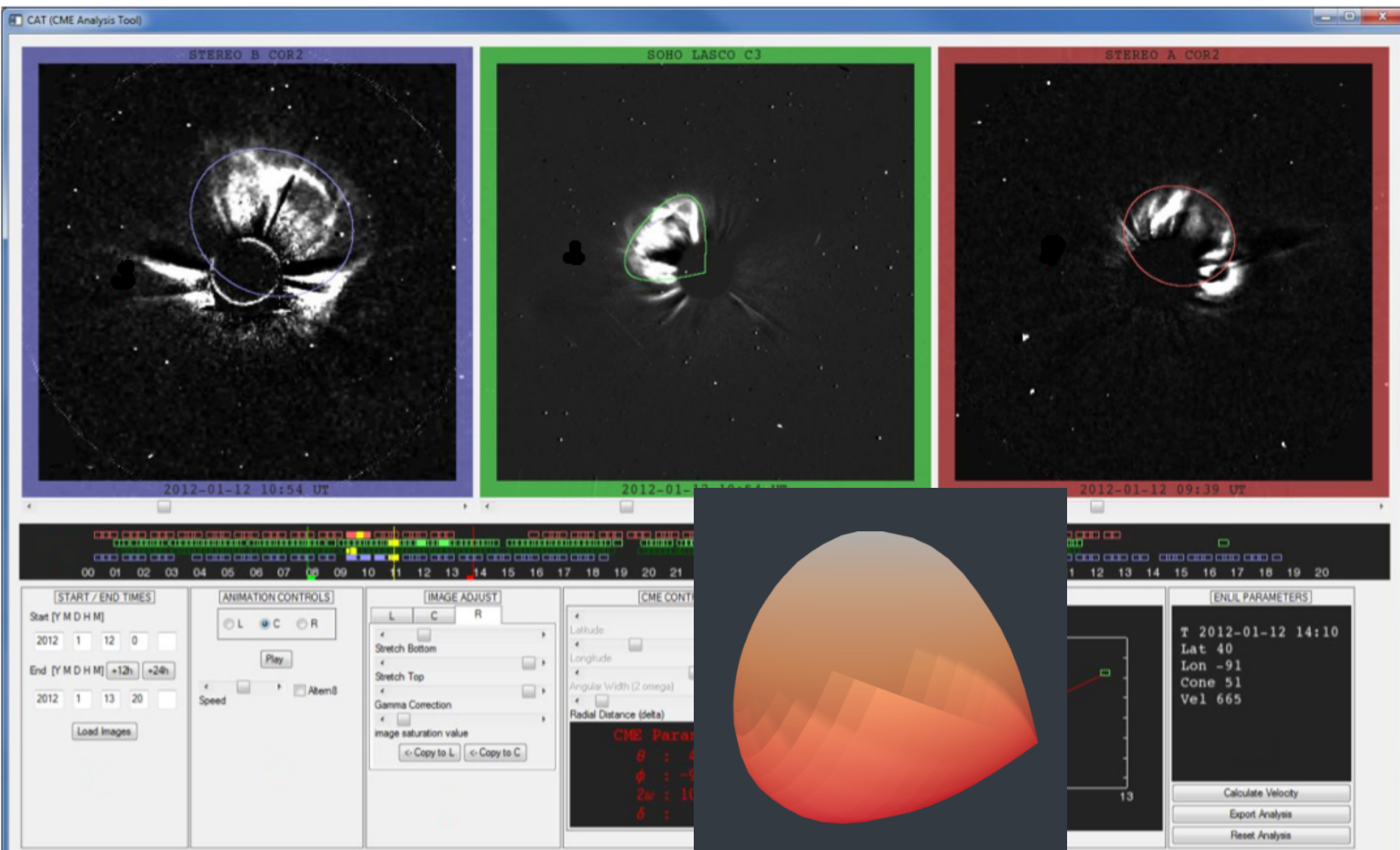
Additionally:

- SWPC\_CAT can be used to fit halo CMEs
- Allows multiple (2 or 3) viewpoints
- the image time stamps do not have to align, after the initial fit

Is not trivial: SWPC\_CAT assumes the shape of the CME is symmetrical (“teardrop” shape), which is not always so.




# The best of both worlds: SWPC\_CAT




# SWPC\_CAT CME analysis Procedure

- \* Before starting the tool, look at coronagraph images in motion (e.g., on iSWA) and identify the CME and the start time (first appearance in a coronagraph).
- \* Look at EUV images in motion near the CME start time (on iSWA) and identify the source location and any lower coronal signatures of the CME (post eruption arcade, dimming, rising loops, filament eruption).
- \* On Where is STEREO tool identify where the satellites are on the date.
- \* Launch SWPC\_CAT\_Web  
[https://ccmc.gsfc.nasa.gov/swpc\\_cat\\_web/](https://ccmc.gsfc.nasa.gov/swpc_cat_web/)
- \* Load the coronagraph images: select the date of the start of the CME in the upper right corner, and press "Load Images" button → two (2) full days-worth of coronagraph difference images (starting with the selected date) is loaded into the top panel of the tool.

# SWPC CAT


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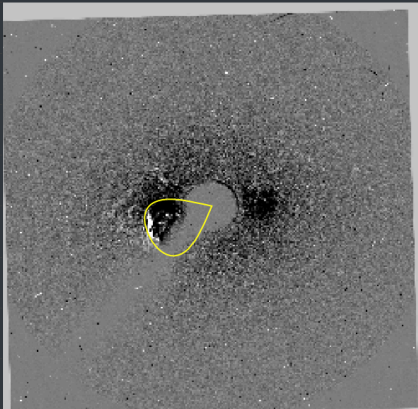
Select Date: 
[Load Images](#)

STEREO B COR2


2014-08-24T18:54:46Z

STEREO B - Running difference


[Match Image](#) [Unmatch Image](#)

SOHO LASCO


2014-08-24T16:54:05Z

SOHO LASCO C3 - Running difference

[Match Image](#) [Unmatch Image](#)

STEREO A COR2


2014-08-24T18:51:20Z

STEREO A - Running difference

[Match Image](#) [Unmatch Image](#)

**IMG-CONTROLS**

[STEREO B](#)
[SOHO](#)
[STEREO A](#)

Stretch Top: 0

Stretch Bottom: 255

Gamma: 0.98

Saturation: 0.23


**CME-CONTROLS**

Latitude: -26.5

Longitude: -83.1

Angular Width: 81.4

Radial Distance: 10.4

**Velocity Graph**


**Results**

Latitude: -26.499999999999996

Longitude: -83.100000000000001

Half-Width: 40.7

Radial Velocity: 310.26


Time at 21.5R: 08/24/2014 23:56:03

[Calculate](#)

# SWPC\_CAT CME analysis Procedure

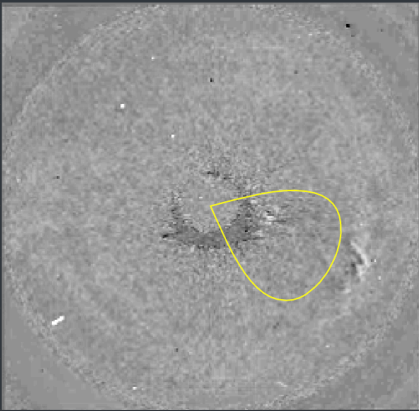
- \* Adjust the images so you can see them well. Use "IMG-CONTROLS" panel (and select the satellite) to play with image saturation, etc. to get a clearer view of the CME.
- \* You can switch between the LASCO C3 and C2 images by clicking on the white bar below the SOHO image frame and selecting "SOHO LASCO C2 – Running Difference" (default is LASCO C3).
- \* Choose a time where you can see the CME well, but also be sure that the CME's width & location isn't varying too rapidly. You're trying to determine the values corresponding to 21.5 R<sub>Sun</sub> (but keep in mind that the earlier images may correspond better with the EUV images).

# SWPC CAT


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Select Date: 08/24/2014
[Load Images](#)

STEREO B COR2



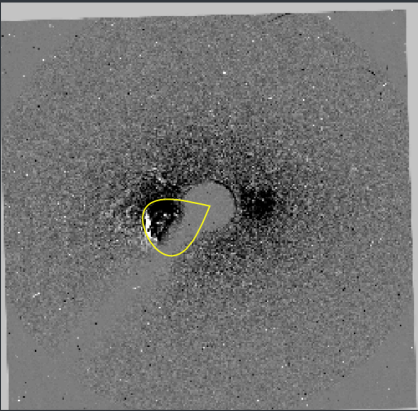
2014-08-24T18:54:46Z

STEREO B - Running difference

Match Image

Unmatch Image

SOHO LASCO




2014-08-24T16:54:05Z

SOHO LASCO C3 - Running difference

Match Image

Unmatch Image

STEREO A COR2



2014-08-24T18:51:20Z

STEREO A - Running difference

Match Image

Unmatch Image

STEREO B

SOHO

STEREO A

IMG-CONTROLS

Stretch Top: 0

0

63

127

191

255

Stretch Bottom: 255

0

63

127

191

255

Gamma: 0.98

0

.25

.5

.75

1

Saturation: 0.23

0

.25

.5

.75

1

CME-CONTROLS

Latitude: -26.5

-90

-45

0

45

90

Longitude: -83.1

-180

-90

0

90

180

Angular Width: 81.4

20

40


90

140

160

Radial Distance: 10.4

Velocity Graph



Results

Latitude: -26.499999999999996

Longitude: -83.100000000000001

Half-Width: 40.7

Radial Velocity: 310.26

Time at 21.5R: 08/24/2014 23:56:03


Calculate

# SWPC\_CAT CME analysis Procedure

- \* Use "CME-CONTROLS" panel to fit the yellow CME outline on the coronagraph images. Experiment with the parameters and do your best to fit all three (or two) viewpoints. Once you think you've got good parameters, go into an image pane and click "CME Matches Image."
- \* **Note: Once you've chosen Latitude/Longitude/Angular Width, you can't change them!** Choose wisely 😊
- \* After this, for each image time, adjust the "Radial Distance" slider until you think it matches closely. Note that the image times do not have to match! Adjust the distance for each image time and select "Match Image."
- \* Every time you click "CME Matches Image" you should see a small box appear on the "Velocity graph" plot (colors of boxes correspond to instruments). Clicking "Calculate" on the Results panel will draw a line fit to the data points and update the values in parameter boxes on Results panel




# SWPC CAT


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Select Date: 08/24/2014
[Load Images](#)

STEREO B COR2



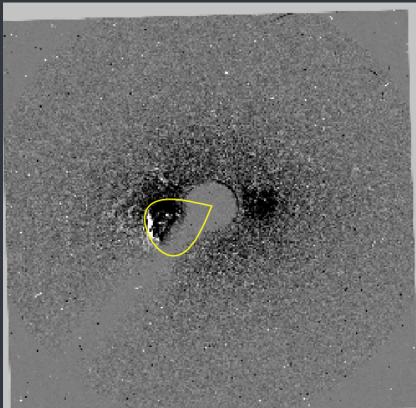
2014-08-24T18:54:46Z

STEREO B - Running difference

Match Image

Unmatch Image

SOHO LASCO




2014-08-24T16:54:05Z

SOHO LASCO C3 - Running difference

Match Image

Unmatch Image

STEREO A COR2



2014-08-24T18:51:20Z

STEREO A - Running difference

Match Image

Unmatch Image

STEREO B

SOHO

STEREO A

Stretch Top: 0

0 63 127 191 255

Stretch Bottom: 255

0 63 127 191 255

Gamma: 0.98

0 .25 .5 .75 1

Saturation: 0.23

CME-CONTROLS

Latitude: -26.5

-90

-45

0

45

90

Longitude: -83.1

-180

-90

0

90

180

Angular Width: 81.4

20

40


90

140

160

Radial Distance: 10.4

Velocity Graph



Results

Latitude:  
-26.499999999999996

Longitude:  
-83.100000000000001

Half-Width: 40.7

Radial Velocity: 310.26

Time at 21.5R:  
08/24/2014 23:56:03

Calculate

# SWPC\_CAT CME analysis Procedure

- Finally, examine the values of your CME parameters in the Results panel – if the speed looks roughly constant (small boxes on the Velocity graph fit the line well), you can use the derived values.
- If it looks like the CME decelerating or accelerating, you may want to "Unmatch" some of the earlier images to make sure the velocity fit is only using the later images (closer to 21.5 R<sub>Sun</sub>).
- The final step is making a screenshot of the whole screen in case you need to reanalyze the CME again or if you are asked to share it with other forecasters (there is no "Save Session" option yet).